

OBLIQUE BURNISH/WIPE MECHANISM FOR HARD DRIVE DISK LIKE MEDIA

Field of Invention

[0001] The present invention relates to the recording, storage and reading of magnetic data, particularly burnishing or wiping rotatable magnetic recording media, such as thin film magnetic disks having smooth surfaces for data zone and apparatus for burnishing or wiping a media surface.

Background

[0002] Magnetic disks and disk drives are conventionally employed for storing data in magnetizable form. Preferably, one or more disks are rotated on a central axis in combination with data transducing heads positioned in close proximity to the recording surfaces of the disks and moved generally radially with respect thereto. Magnetic disks are usually housed in a magnetic disk unit in a stationary state with a magnetic head having a specific load elastically in contact with and pressed against the surface of the disk. Data are written onto and read from a rapidly rotating recording disk by means of a magnetic head transducer assembly that flies closely over the surface of the disk. Preferably, each face of each disk will have its own independent head.

[0003] A disk recording medium is shown in Fig. 1. Even though Fig. 1 shows sequential layers on one side of the non-magnetic substrate 10, it is to sputter deposit sequential layers on both sides of the non-magnetic substrate.

[0004] Adverting to Fig. 1, a sub-seed layer 11 is deposited on substrate 10, e.g., a glass or glass-ceramic, Al or AlMg substrate. Subsequently, a seed layer 12 is deposited on the sub-seed layer 11. Then, an underlayer 13, is sputter deposited on the seed layer 12. An intermediate or flash layer 14 is then sputter deposited on underlayer 13.

Magnetic layer 15 is then sputter deposited on the intermediate layer, e.g., CoCrPtTa. A protective covering overcoat 16 is then sputter deposited on the magnetic layer 15. A lubricant topcoat (not shown in Fig. 1 for illustrative convenience) is deposited on the protective covering overcoat 16.

[0005] The disk is finely balanced and finished to microscopic tolerances. Take the smoothness of its surface, for example. The drive head rides a cushion of air at microscopic distances above the surface of the disk. So, the surface cannot be too smooth, or the drive head will end up sticking to the disk, and it cannot be too rough either, or the head will end up getting caught in the microscopic bumps on the surface.

[0006] It is considered desirable during reading and recording operations to maintain each transducer head as close to its associated recording surface as possible, i.e., to minimize the flying height of the head. This objective becomes particularly significant as the areal recording density increases. The areal density (Mbits/in^2) is the recording density per unit area and is equal to the track density (TPI) in terms of tracks per inch times the linear density (BPI) in terms of bits per inch.

[0007] In recent years, considerable effort has been expended to achieve high areal recording density. In particular, the requirement to further reduce the flying height of the head imposed by increasingly higher recording density and capacity renders the disk drive particularly vulnerable to head crash due to accidental glide hits of the head and media. To avoid glide hits, a smooth defect-free surface of data zone is desired. The direct result of these demands is tending towards low yield due to less defect tolerance at the surface of the media. Thus, it is desired to arrive at an improved mechanism for burnishing/polishing the surface of the discs to produce defect-free surface.

Summary of the Invention

[0008] This invention relates to a cleaning apparatus comprising an article, a burnishing object positioned over or under the article, and a device that (a) rotates the burnishing object at an offset angle that is variable over an area of the article and (b) translates the burnishing object relative to the article to advance a position of a contact of the burnishing object with the article across a surface of the article. Preferably, the burnishing object is not contacted to the article by air directed to the burnishing object and the article is a rotating disk. Also, preferably the offset angle changes as the position of the contact advances from an inner diameter to an outer diameter of the disk. Preferably, the cleaning apparatus removes particles from the surface of the article. Preferably, the device simultaneously rotates and translates the burnishing object and the device creates a wiper blade motion of the burnishing object on the surface of the article. Preferably, the device allows the burnishing object to make and break the contact of the burnishing object with the article across the surface of the article. In one embodiment, the burnishing object is a tape or a pad.

[0009] Another embodiment is a method of operating a cleaning apparatus comprising an article and a burnishing object positioned over or under the article, the method comprising (a) rotating the burnishing object at an offset angle that is variable over an area of the article and (b) translating the burnishing object relative to the article to advance a position of a contact of the burnishing object with the article across a surface of the article.

[0010] Another embodiment is a cleaning apparatus comprising an article, a burnishing object positioned over or under the article, and means for simultaneously translating and rotating the burnishing object on the article.

[0011] Additional advantages of this invention will become readily apparent to those skilled in this art from the following detailed description, wherein only the preferred embodiments of this invention is shown and described, simply by way of illustration of the best mode contemplated for carrying out this invention. As will be realized, this invention is capable of other and different embodiments, and its details are capable of modifications in various obvious respects, all without departing from this invention. Accordingly, the drawings and description are to be regarded as illustrative in nature and not as restrictive.

Brief Description Of The Drawings

[0012] Fig. 1 schematically shows a film structure of a magnetic recording medium.

[0013] Fig. 2 schematically illustrates an exemplary burnishing mechanism.

[0014] Fig. 3 shows an exemplary device of the burnishing apparatus, the device having both translational and rotational movements.

Detailed Description

[0015] Almost all the manufacturing of the disks takes place in clean rooms, where the amount of dust in the atmosphere is kept very low, and is strictly controlled and monitored. The disk substrates come to the disk fabrication site packed in shipping cassettes. For certain types of media, the disk substrate has a polished nickel-coated surface. The substrates are preferably transferred to process cassettes to be moved from

one process to another. Preferably, the cassettes are moved from one room to another on automatic guided vehicles to prevent contamination due to human contact.

[0016] The first step in preparing a disk for recording data is mechanical texturing by applying roughness and grooves to the polished surface of the substrate. This helps in depositing a magnetic material on the substrate. During the texturing process, small amounts of nickel get removed from surface of the disk and remain there. To remove this, the substrate is usually washed. Also, techniques for polishing the surface of the non-magnetic substrate of a recording medium use slurry polishing, which requires wash treatment. Thus, disk substrates are washed after texturing and polishing. However, wash defects could be one of the top yield detractors.

[0017] The next step is the formation of the landing area (preferably, a 2-4 mm band near the center) where the read head comes to rest. Preferably, the landing area is formed by laser texturing, which is done by creating microscopic bumps, using a laser. This prevents the head from clinging to the disk surface when the disk is spinning.

[0018] A final cleaning of the substrate is then done using a series of ultrasonic, megasonic and quick dump rinse (QDR) steps. At the end of the final clean, the substrate has an ultra-clean surface and is ready for the deposition of layers of magnetic media on the substrate. Preferably, the deposition is done by sputtering.

[0019] Sputtering is perhaps the most important step in the whole process of creating recording media. There are two types of sputtering: pass-by sputtering and static sputtering. In pass-by sputtering, disks are passed inside a vacuum chamber, where they are bombarded with the magnetic and non-magnetic materials that are deposited as one or

more layers on the substrate. Static sputtering uses smaller machines, and each disk is picked up and sputtered individually.

[0020] The sputtering layers are deposited in what are called bombs, which are loaded onto the sputtering machine. The bombs are vacuum chambers with targets on either side. The substrate is lifted into the bomb and is bombarded with the sputtered material.

[0021] Sputtering leads to some spike formation on the substrate. These spikes need to be removed to ensure that they do not lead to the scratching between the head and substrate. Thus, a lube is preferably applied to the substrate surface as one of the top layers on the substrate.

[0022] Once a lube is applied, the substrates move to the tape burnishing and tape wiping stage, where the substrate is polished while it preferentially spins around a spindle. After buffing/burnishing, the substrate is wiped and a clean lube is evenly applied on the surface.

[0023] Subsequently, the disk is prepared and tested for quality thorough a three-stage process. First, a burnishing head passes over the surface, removing any bumps (asperities as the technical term goes). The glide head then goes over the disk, checking for remaining bumps, if any. Finally the certifying head checks the surface for manufacturing defects and also measures the magnetic recording ability of the substrate.

[0024] A technique for buffing/burnishing is tape burnishing (buffing). However, the technique is attendant with numerous disadvantages. For example, it is extremely difficult to provide a clean and smooth surface due to debris formed by mechanical abrasions.

[0025] Tape burnish and tape wipe processes in which the tape moves orthogonal to the burnishing object without any rotational degree of freedom of the burnishing tape cannot generally effectively remove the particles on the surface of the disk. These particles cause failure and/or decreased performance of the magnetic disc drives. This problem can be especially critical in magnetic discs made by the servo pattern printing process. This is because the particles on the surface can damage the stamper, which sequentially affects the quality of the printed discs. This invention allows the tape burnishing and tape wiping processes to be improved to meet the demands of high storage density and low fly height criteria.

[0026] The cleaning apparatus for burnishing asperities or defects from the surfaces of an article, e.g., a rigid magnetic disk, could use an abrasive burnishing tape, a pad, a cloth, a scrubber or any burnishing object that contacts and cleans the surface of the object. If the object is a disk, then the disk preferably rotates on a spindle while the burnishing object contacts the surface of the disk. The burnishing object could be held stationary at one location on the surface of the disk or moved during the burnishing process.

[0027] In one embodiment, the burnishing object is contacted to the article by air directed to the burnishing object. On the other hand, in another embodiment, the burnishing object is not contacted to the article by air directed to the burnishing object.

[0028] The trajectory of the burnishing object relative to the burnished disc can be controlled to optimize the particle removal effectiveness. A preferred embodiment is an oblique tape burnish mechanism that would allow extra rotation degree of freedom besides the translational degree of freedom to effectively remove the particles from the

surface of a rotating disk. The oblique angle of the mechanism can be adjusted so that the kinematical condition can be optimized relative to the motion of the area of the disk being burnished. The oblique angle provide a condition to load and unload the burnishing object on the disc which could maximize the burnish area at the inner and outer diameters of the discs which are other difficult to burnish with a burnishing device with just translational degree of freedom. The combined translation and rotation motion of the burnish pad simulates particle “wiping down” motion.

[0029] Figure 2 shows one embodiment of the burnishing apparatus on the surface of a disk with outer and inner diameters of 22 and 30, respectively. The burnishing apparatus includes a burnishing object 19, shown as a shaded object, which could be a burnishing tape, extending along the arm 20 of the burnishing apparatus. The angle between the arm 20 and a line passing through the center of disk is called the offset angle and is designated as “ α ” for the particular angle shown in Figure 2.

[0030] In one embodiment, the process sequence for burnishing are the following: (1) Position the center of the burnishing object at location 1 on the disk and set the offset angle at α . (2) Translate the center of burnishing object linearly to location 2 on the disk while maintaining the offset angle at α . (3) Rotate the arm and change the offset angle to β while maintaining the center of the burnishing object at location 2.

[0031] In one embodiment, the process sequence for burnishing are the following: (1) Position the center of the burnishing object at location 1 on the disk and set the offset angle at α . (2) Translate the center of burnishing object linearly to location 2 on the disk while rotating the arm and changing the offset angle to β .

[0032] In yet another embodiment, the process sequence for burnishing are the following: (1) Position the center of the burnishing object at location 1 on the disk and set the offset angle at α . (2) Translate the center of burnishing object linearly to location 2 on the disk while rotating the arm and changing the offset angle to β . (3) Translate the center of burnishing object linearly to location 3 near the outer diameter 22 of the disk while rotating the arm and changing the offset angle to γ .

[0033] Other embodiments could be any combinations of the above embodiments. In addition, other kinematical conditions that allow both translational and rotational movements of the burnishing object are possible.

[0034] Figure 3 shows another embodiment of a device burnishing apparatus that allows both translational and rotational movements of the burnishing object. This device has two arms. The first arm has translational movement. The second arm is pivotally attached to the first arm and has rotational movement. The burnishing object is attached to the second arm. The combined movements of the first and second arms allow the burnishing object to have both translational and rotational movements, sequentially or simultaneously, over the surface of a burnished article.

[0035] The asperities on the surface of the burnished article are less than 5 nm, preferably less than 4 nm, most preferably less than 3 nm. The surface parameters can be measured by atomic force microscope (AFM) such as NanoScope.[®] The statistics used by the AFM are mostly derived from ASME B46.1 (“Surface Texture: Surface Roughness, Waviness and Lay”) available from the American Society of Mechanical Engineers, which is incorporated herein by reference.

[0036] The parameters for measuring surface roughness due to asperities are the following:

(1) Average surface roughness (R_a): Arithmetic average of the absolute values of the surface height deviations measured from a mean plane. The value of the mean plane is measured as the average of all the Z values within an enclosed area. The mean can have a negative value because the Z values are measured relative to the Z value when the microscope is engaged. This value is not corrected for tilt in the plane of the data; therefore, plane fitting or flattening the data will change this value.

$$R_a = [|Z_1| + |Z_2| + \dots + |Z_n|]/N$$

(2) RMS: This is the standard deviation of the Z values within the enclosed area and is calculated as

$$RMS = [\{ \Sigma (Z_i - Z_{avg})^2 \} / N]^{1/2}$$

where Z_{avg} is the average of the Z values within the enclosed area, Z_i is the current Z value, and N is the number of points within the enclosed area. The RMS value is not corrected for tilt in the plane of the data; therefore, plane fitting or flattening the data will change this value.

(3) Maximum height (R_{max}): This the difference in height between the highest and lowest points on the surface relative to the mean plane.

(4) R_z : This is the average difference in height between five highest peaks and five lowest valleys relative to the mean plane.

[0037] All of surface parameters would be improved remarkably after the burnish process of this invention. For example, the surface roughness average R_a can be reduced from about 3 nm to about 0.3 nm. The surface parameter RMS can be decreased from

about 4 nm to about 0.4 nm. The surface parameter R_{\max} can be reduced from about 15 nm to about 2 nm. The surface parameter R_z can be reduced from about 9 nm to about 2 nm.

[0038] In other embodiments, the moving tape is applied to the surface with a pad or a roller forcing the tape to contact the surface or there is an additional wiping process. For a tape burnishing process, the tape could have 0.3 micron alumina on a tape of a polyester material. The contact force on the disk could be adjusted to gram accuracy. The spindle rotation speed of disk could be about 600 rpm. The tape moving speed could be about 8 inch per minute. The contact time could be about three seconds or more. After burnishing, a wiping process could be carried out with a woven fabric polyester or cotton material. The wiping time could be about three second with a disk rotation speed of about 400 rpm and tape speed of about 4 inch per minute. The wiping process would prepare a clean surface for AFM measurement.

[0039] In other embodiments, the burnishing process is combined with a wash process, which could precede or follow the burnishing process, and these processes could be used before or after the thin film sputter deposition on the surface of a non-magnetic substrate. The method of this invention can be used on a non-magnetic substrate comprising glass, NiP/aluminum, metal alloys, plastic/polymer material, ceramic, glass-ceramic, glass-polymer and other composite materials.

[0040] The wash process, if implemented, could use acidic cleaners that have pH range 1 to 5, preferably, 1.5 to 4 used to treat a fresh surface of the rigid disk just following the mechanical texture. The acidic cleaner could be sprayed on the disk

surface for a short time then followed by DI water spraying. Optionally, after the acidic cleaner treatment the disk could be soaked in the alkaline soap solution.

[0041] In other embodiments of this invention the variations in buffing, i.e., polishing, the surface that can be employed are any one or more of the methods shown below.

Mechanical Polishing

[0042] Persons skilled in this art would recognize that the variables that control mechanical polishing are: (a) substrate surface initial condition: roughness, waviness, substrate size, substrate shape and grain size; (b) polishing slurry size (Al_2O_3 , CeO_2 , SiO_2 , etc) and coolant (inorganic and organic solutions with lubricant); (c) polishing time and surface finishing; and (d) washing and cleaning substrate surface.

Chemical Polishing

[0043] Persons skilled in this art would recognize that the variables that control chemical polishing are: (a) substrate surface initial condition: roughness, waviness, substrate size, substrate shape and grain size; (b) polishing solutions compositions and their ability to dissolve the substrate materials; (c) the composition consists of a combination of different acids (e.g. nitric, sulfuric, hydrochloric, phosphoric, chromic, acetic) or organic solutions (e.g. methanol, glycerin, ethyldiglicol), also containing some added electropositive ions. E.g., polishing of Al: small amounts of Cu will create additional local cathodes by deposition on Al, stimulating the polishing process. Adding some oxidants has a function as depolarization agents.

Electrochemical Polishing

[0044] Persons skilled in this art would recognize that the variables that control electrochemical polishing are: (a) the external source of electricity to produce the anodic current density and voltage; (b) the electrolyte temperature; (c) the time duration of electropolishing; (d) the cathodic materials; in general, the cathode surface should be many times larger than that of electropolished substrate and different materials are used as cathodes depending on the applied electrolyte; and (e) agitation, which can eliminate the undesired concentration of the dissolved material at the substrate. Agitation can improve the supply of fresh electropolishing electrolyte to substrate surface. Agitation can prevent local heating and release gas bubbles from the polished surface to avoid pitting on the substrate surface.

[0045] CMP (Chemical Mechanical Polishing) used in semiconductor wafer polishing. Persons skilled in this art would recognize that the variables that control the CMP process.

[0046] The above description is presented to enable a person skilled in the art to make and use the invention, and is provided in the context of a particular application and its requirements. Various modifications to the preferred embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Thus, this invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein. Finally, the entire disclosure of the patents and publications referred in this application are hereby incorporated herein by reference.